Disappearance of the East Korean Warm Current in the southwestern East/Japan Sea

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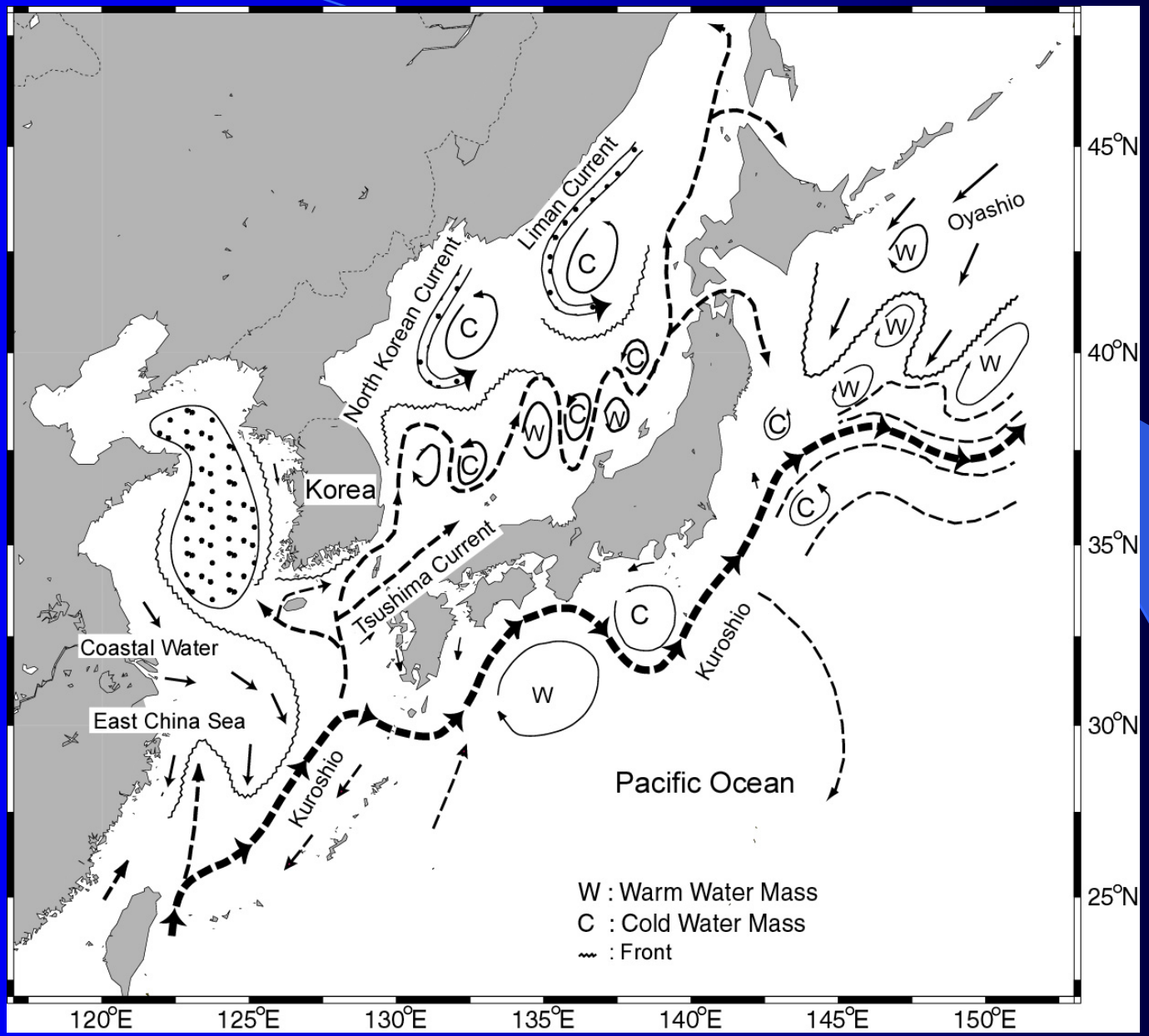
PICES/POC

Oct. 14, 2003, Seoul, Korea


Liman Current
North Korean Current
Oyashio
Korea
Tsushima Current
Coastal Water
East China Sea
Kuroshio
Kuroshio
Pacific Ocean
W : Warm Water Mass
C : Cold Water Mass
: Front
45°N
40°N
35°N
30°N
25°N
120°E
125°E
130°E
135°E
140°E
145°E
150°E

Flow patterns of the Tsushima (Warm) Current

Branching view (since Suda and Hidaka, 1932; Katoh, 1994; Hase et al., 1999):
- First branch (Nearshore branch, NB)
- Second branch (Offshore branch, OB)
- Third branch (East Korean Warm Current, EKWC)

Meandering view (since Tanioka, 1968; Moriyasu, 1972)

Alternation (Naganuma, 1973, 1977, 1985)

* Mostly based on 100 m T and/or dynamic topography at upper depths

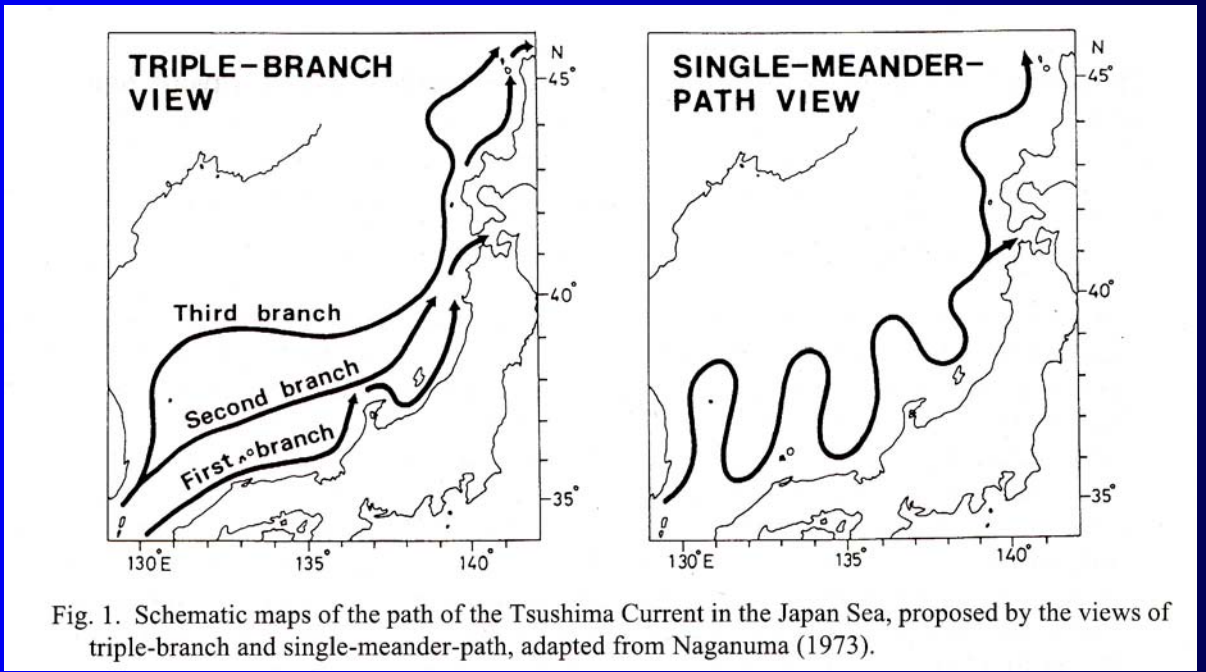
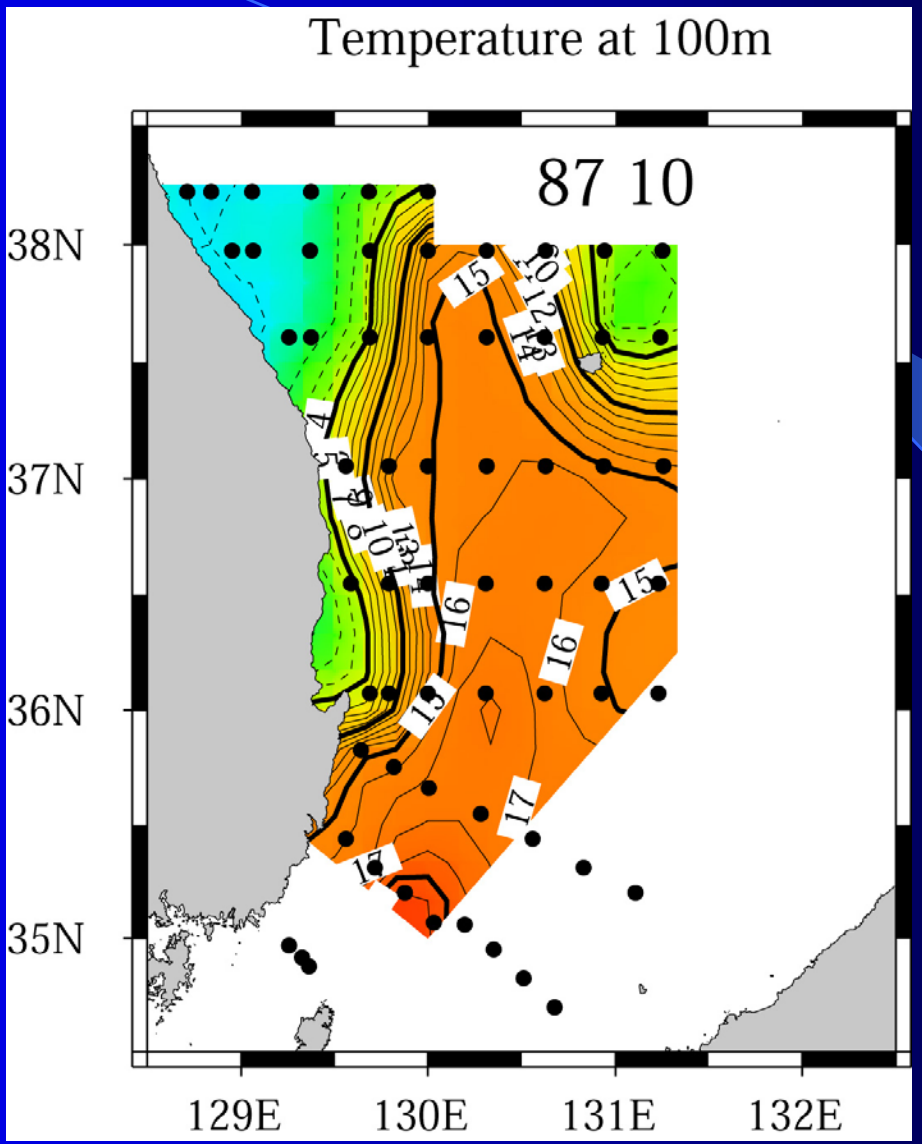
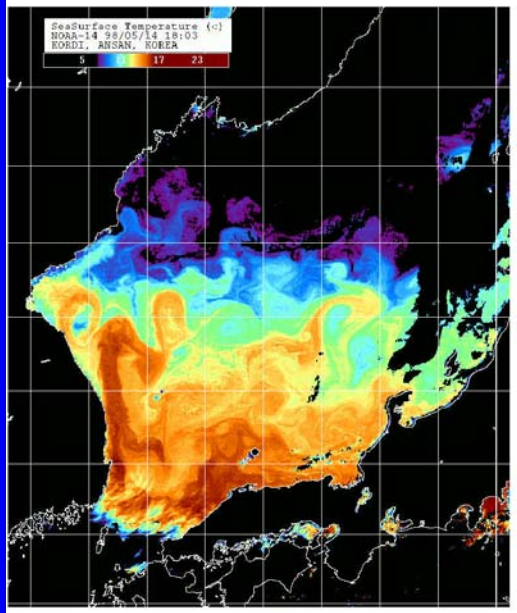


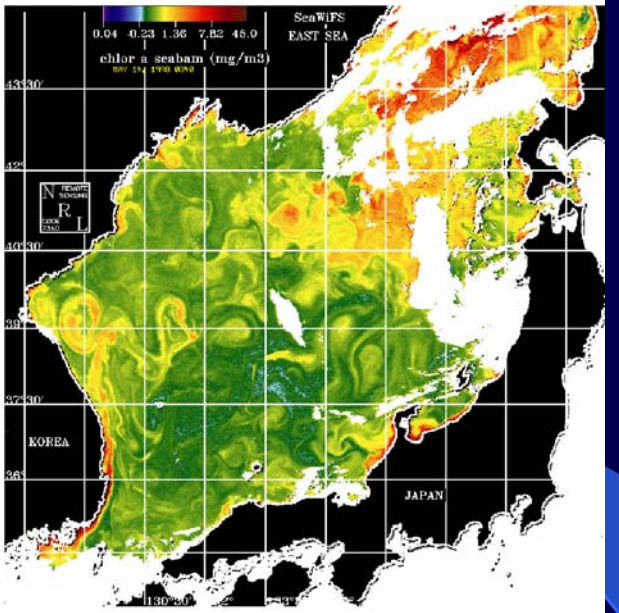
Fig. 1. Schematic maps of the path of the Tsushima Current in the Japan Sea, proposed by the views of triple-branch and single-meander-path, adapted from Naganuma (1973).


Temperature at 100m
87 10
38N
37N
36N
35N
129E
130E
131E
132E

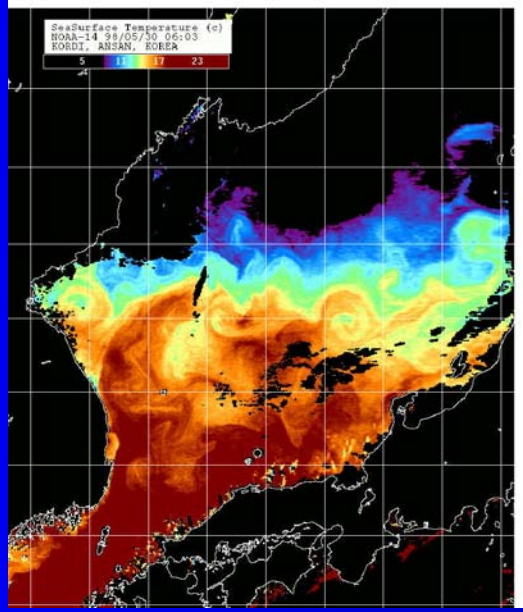
(a) MCSST on May 14, 1998



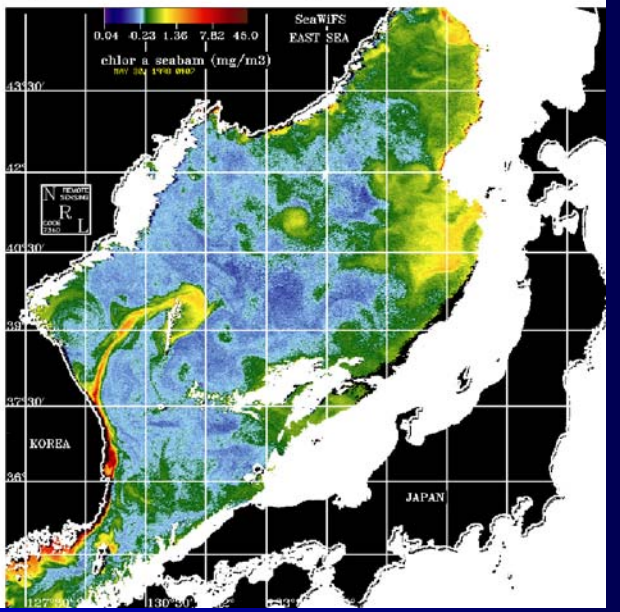
(b) Ocean color on May 14, 1998

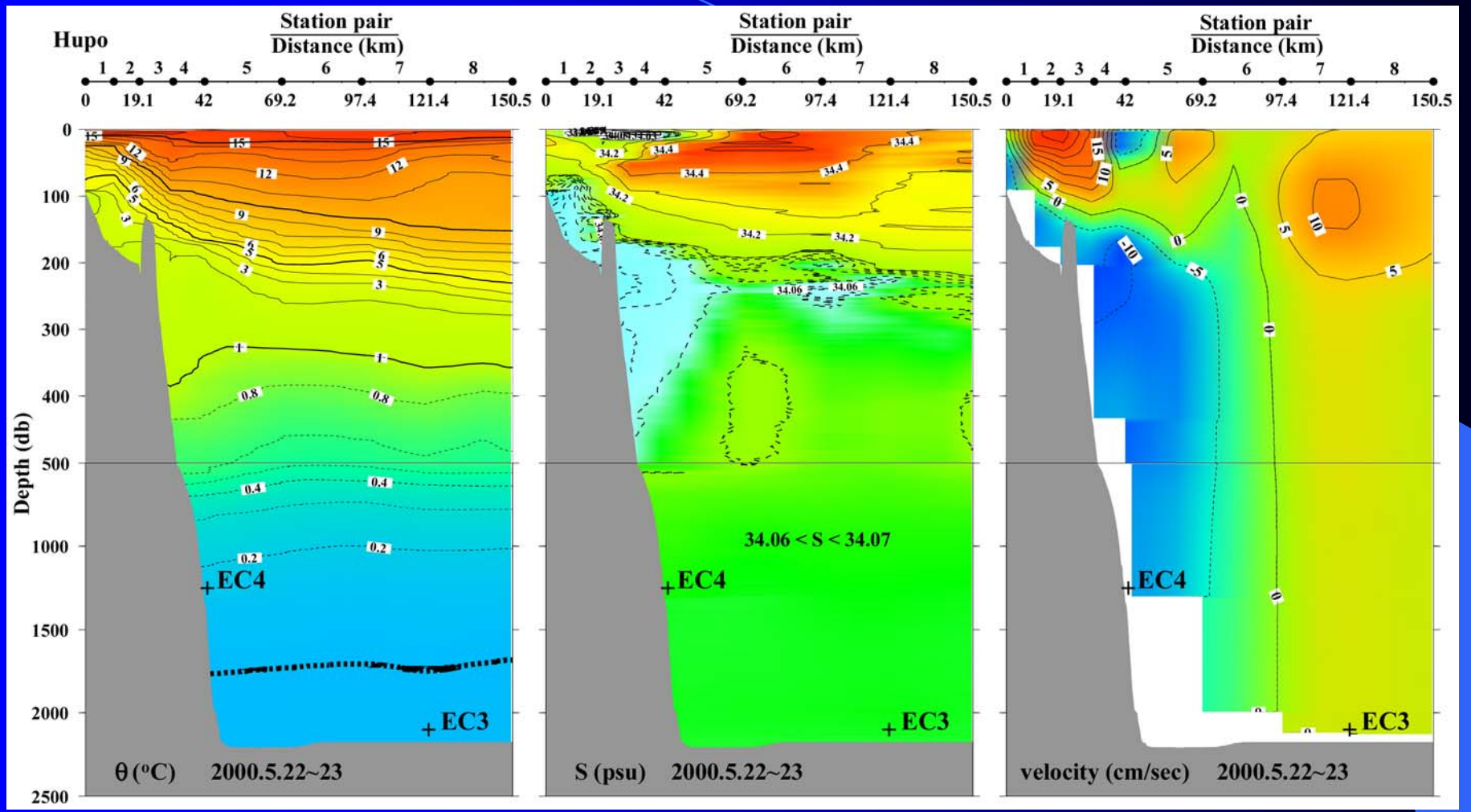


(c) MCSST on May 30, 1998



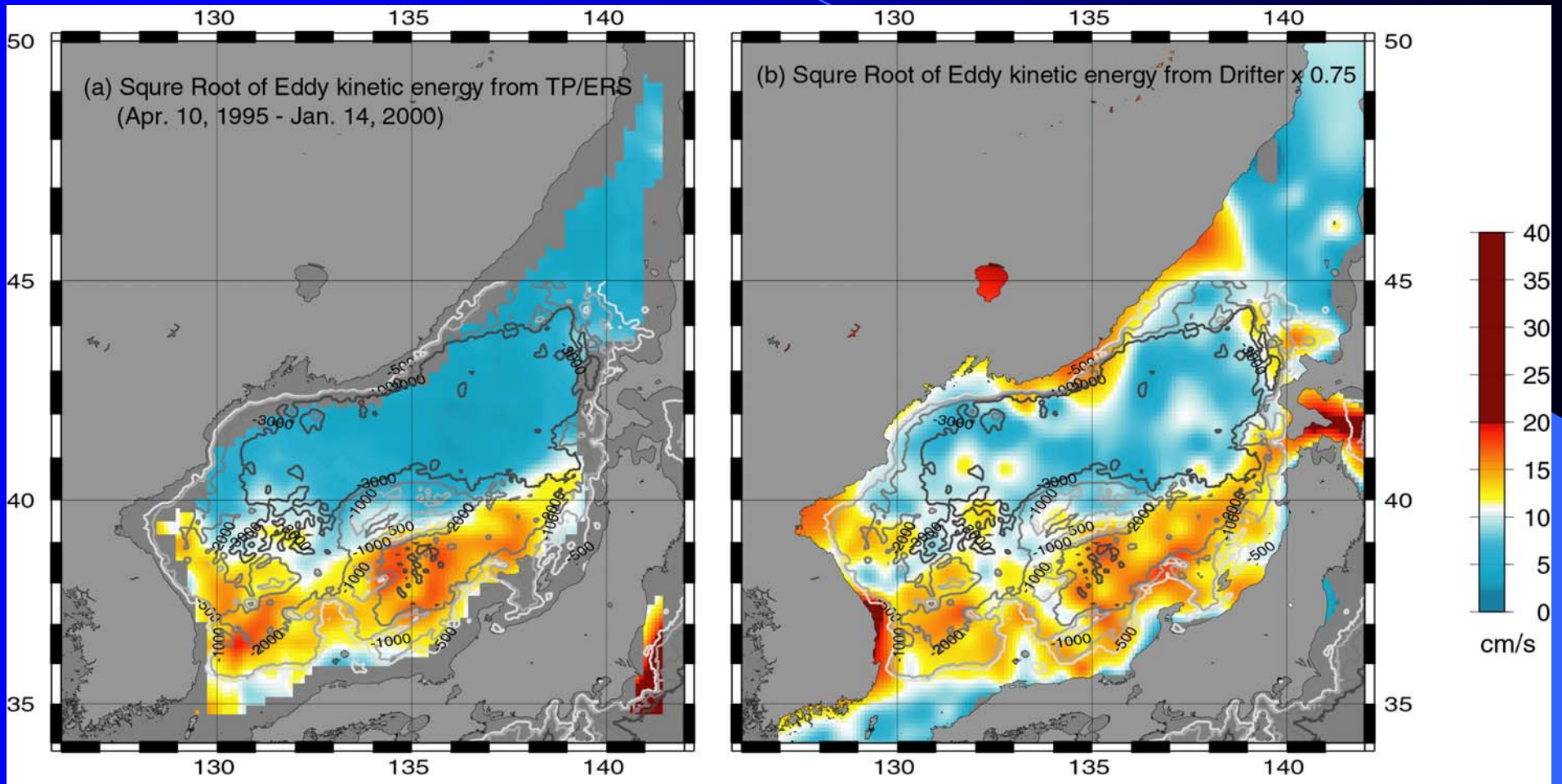
(d) Ocean color on May 30, 1998



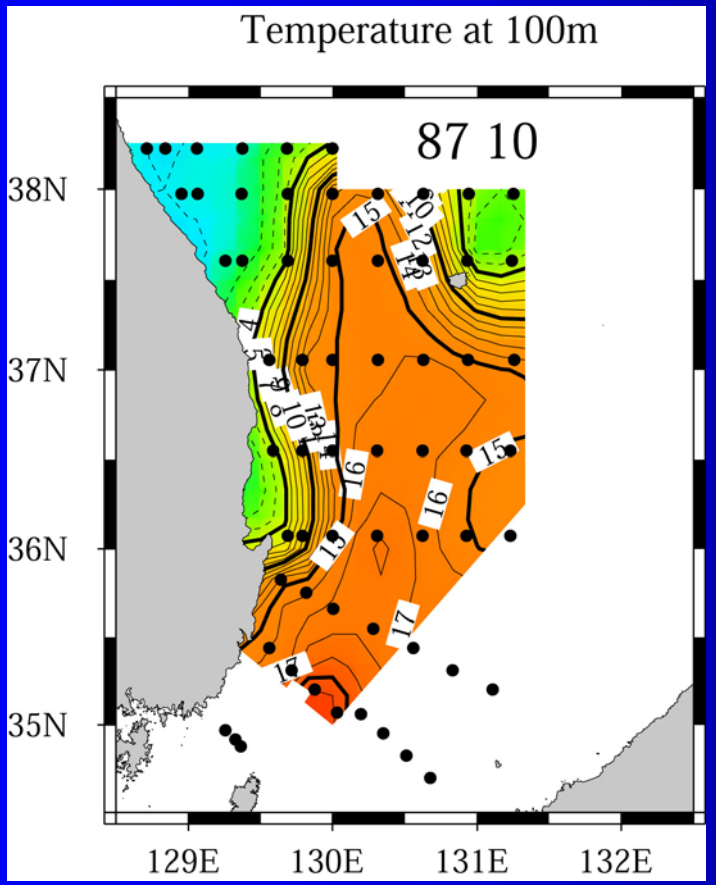

Hupo
Station pair
Distance (km)
1 2 3 4 5 6 7 8
0 19.1 42 69.2 97.4 121.4 150.5
Depth (db)
0 100 200 300 400 500 1000 1500 2000 2500
EC4
EC3
θ (°C) 2000.5.22~23
S (psu) 2000.5.22~23
34.06 < S < 34.07
velocity (cm/sec) 2000.5.22~23

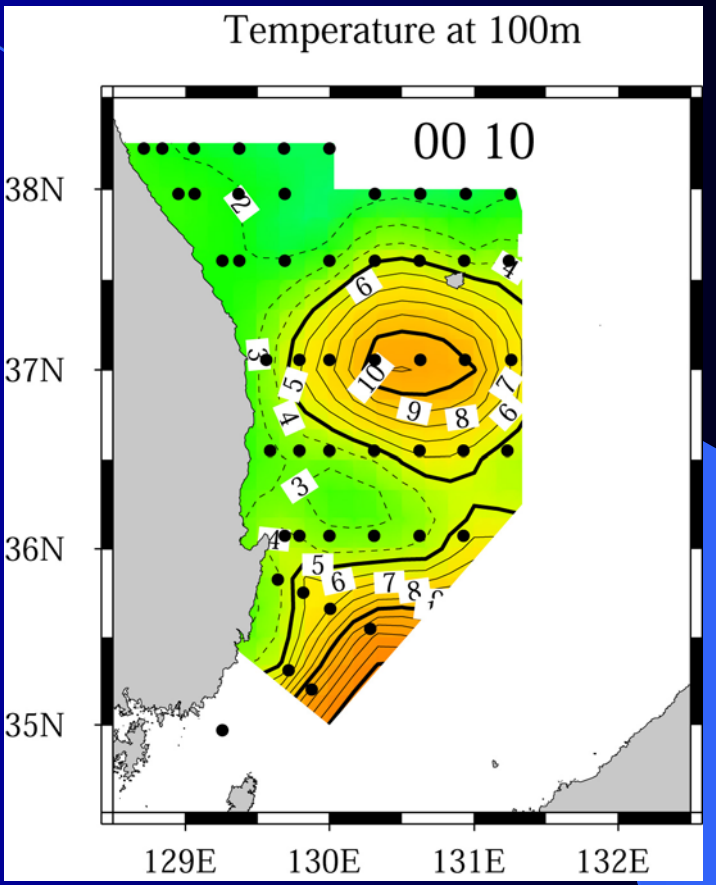
Surface EKE in the East/Japan Sea

(Lee et al., 2001)



Eddy kinetic energy calculated from (a) TP/ERS sea level anomaly and (b) drifter observations. Colors are eddy kinetic energy and contours are Bottom topography.

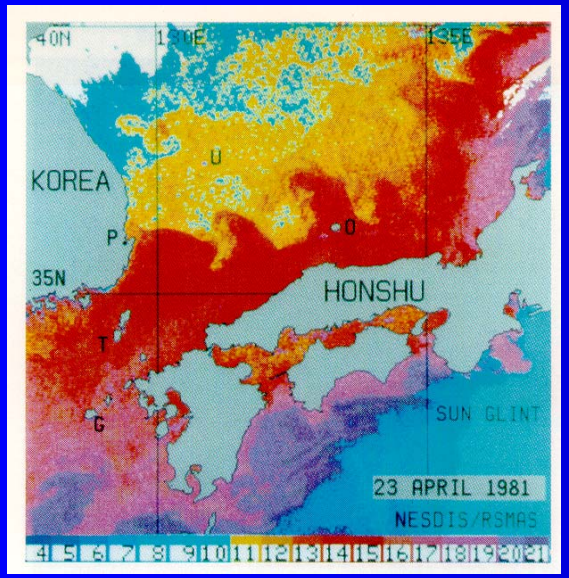

Temperature at 100m
87 10
38N
37N
36N
35N
129E
130E
131E
132E


Temperature at 100m
00 10
38N
37N
36N
35N
129E
130E
131E
132E

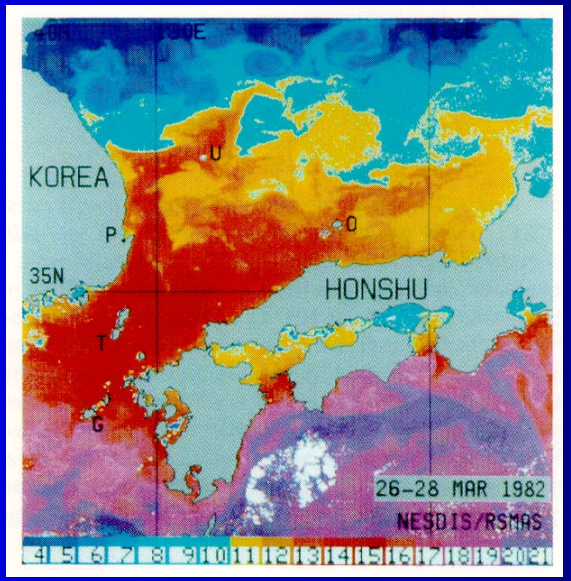
Variability of the EKWC

Disappearance of the EKWC: Kim and Legeckis (1986) - April 1981
Hong et al. (1984) - summer 1981
Cho and Kim (1996) - February 1989~1992
Eddy intrusion process in spring and summer: Isoda and Saitoh (1993)

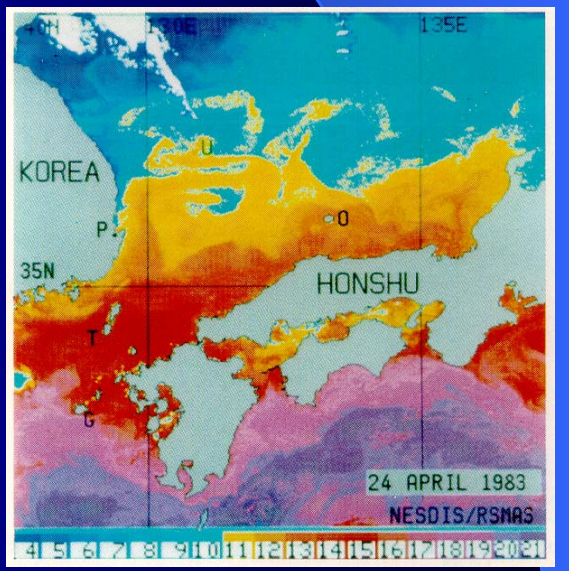
April 23, 1981



March 26~28, 1982



April 24, 1983



Variability of upper circulation in August

Katoh (1994) based on hydrographic data during 1976~1990

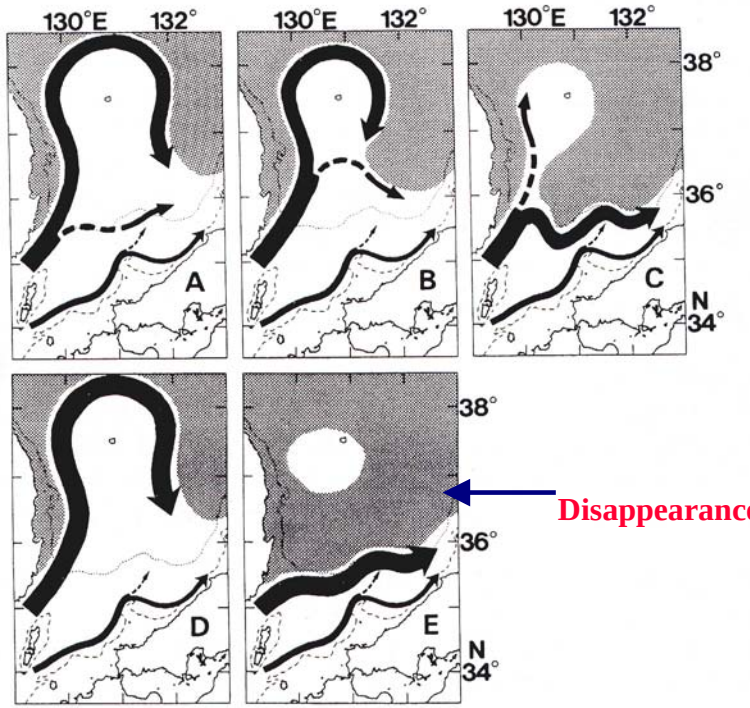
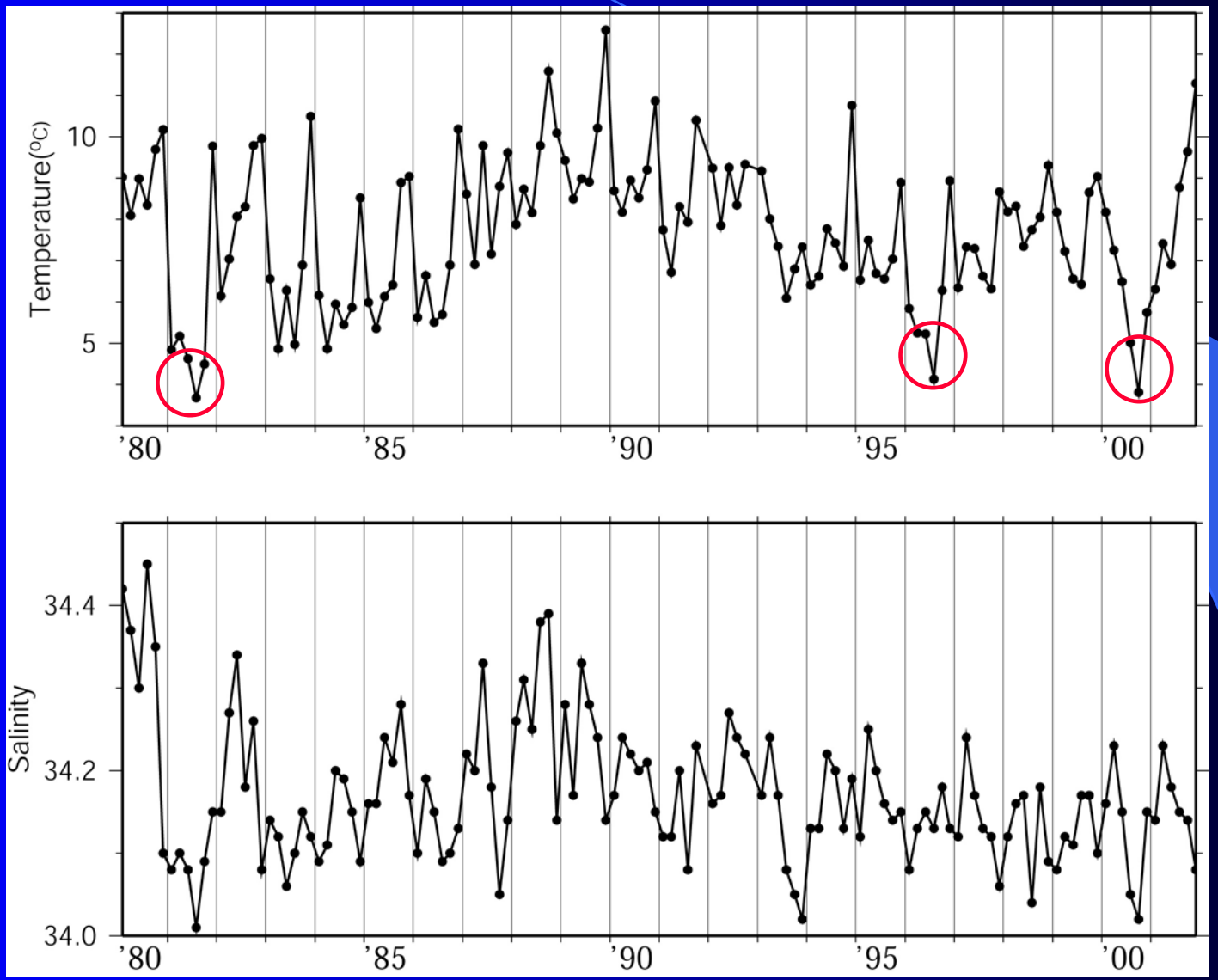
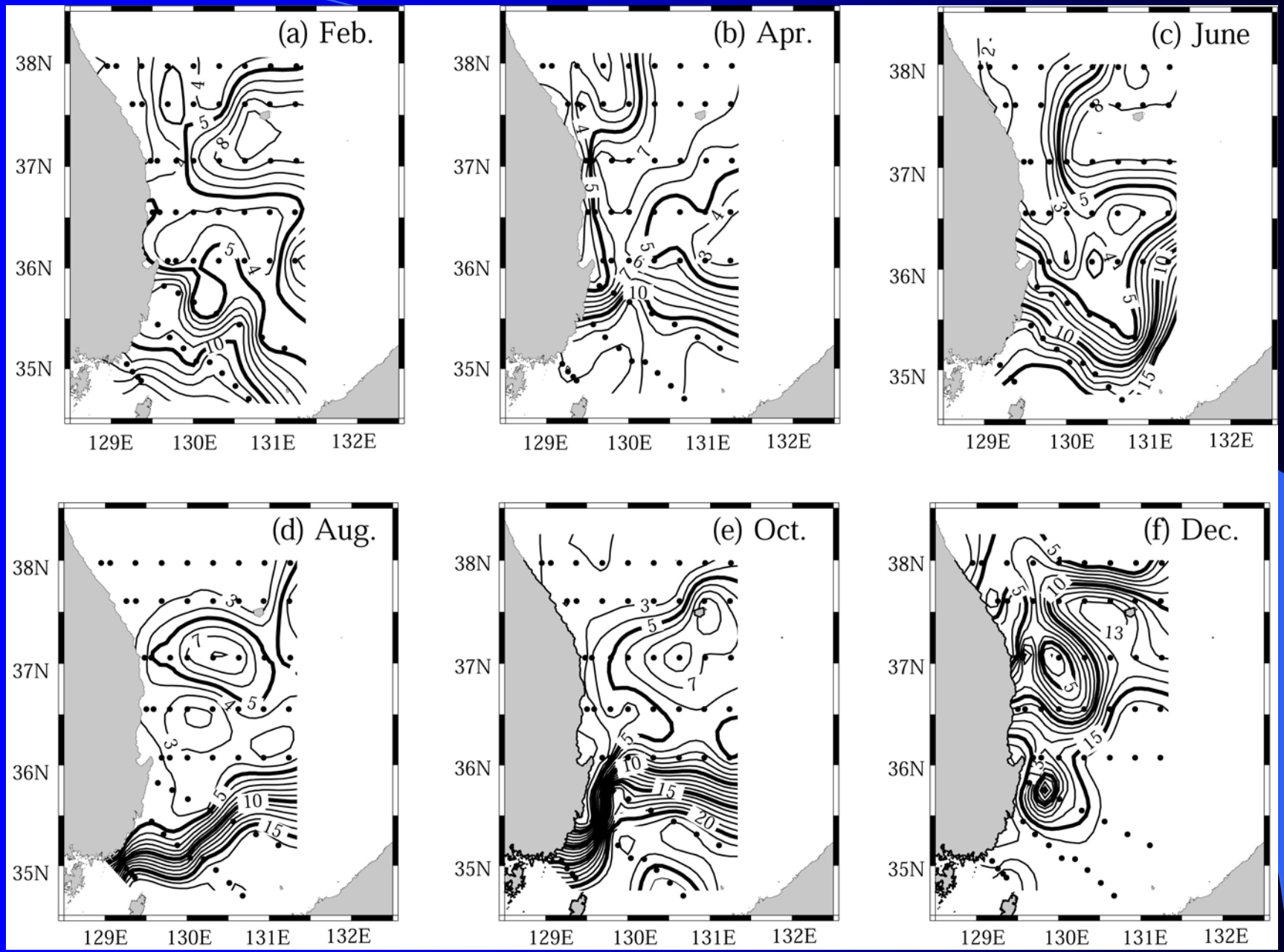
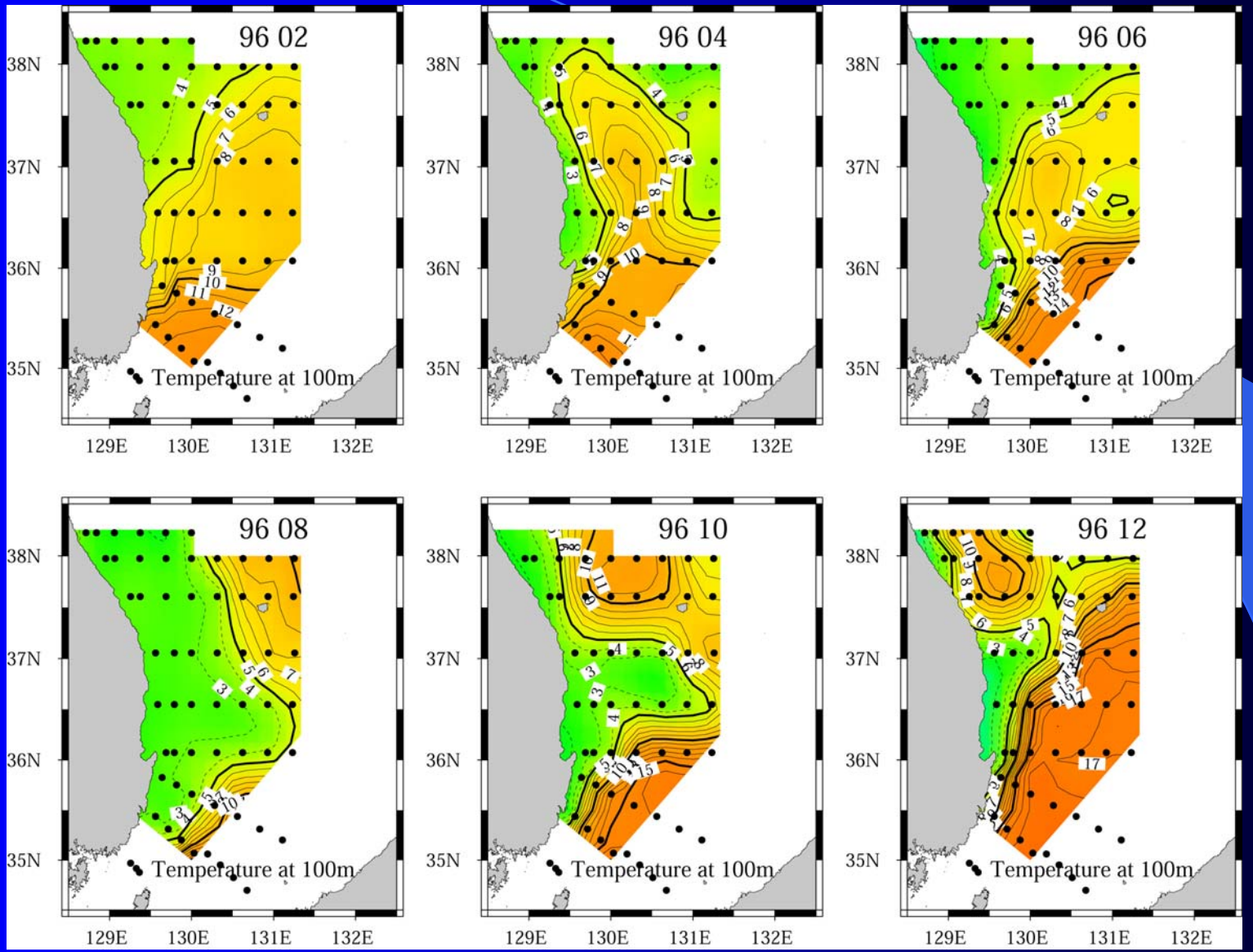


Fig. 13. Examples of patterns of the bifurcation into the second and third branches of the Tsushima Current. The first branch is shown as a fixed pattern, since it is thought to be steady (Katoh, 1994). Broken parts of paths indicate intermittent or transient bifurcations. The hatched section shows the area occupied by cold water. Pattern A is different from pattern B as explained by the following point: The second branch is shown to be over the continental shelf in pattern A, while in offshore area with water depth below 200 m in pattern B.

Bi-monthly variation of basin-averaged T_{100}

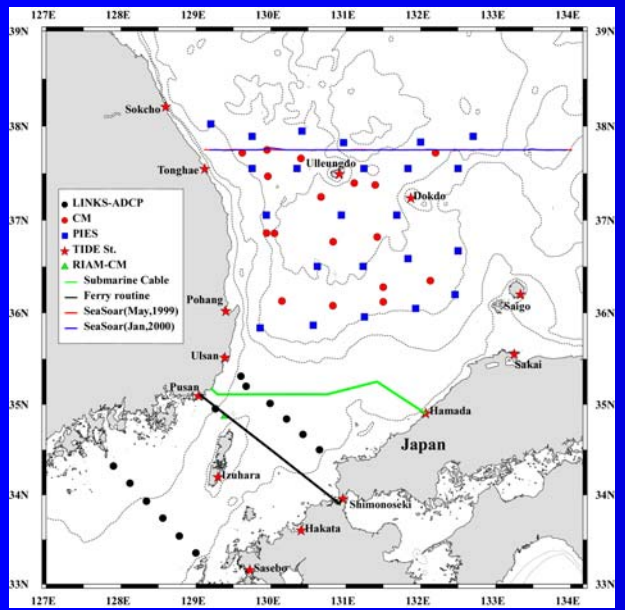


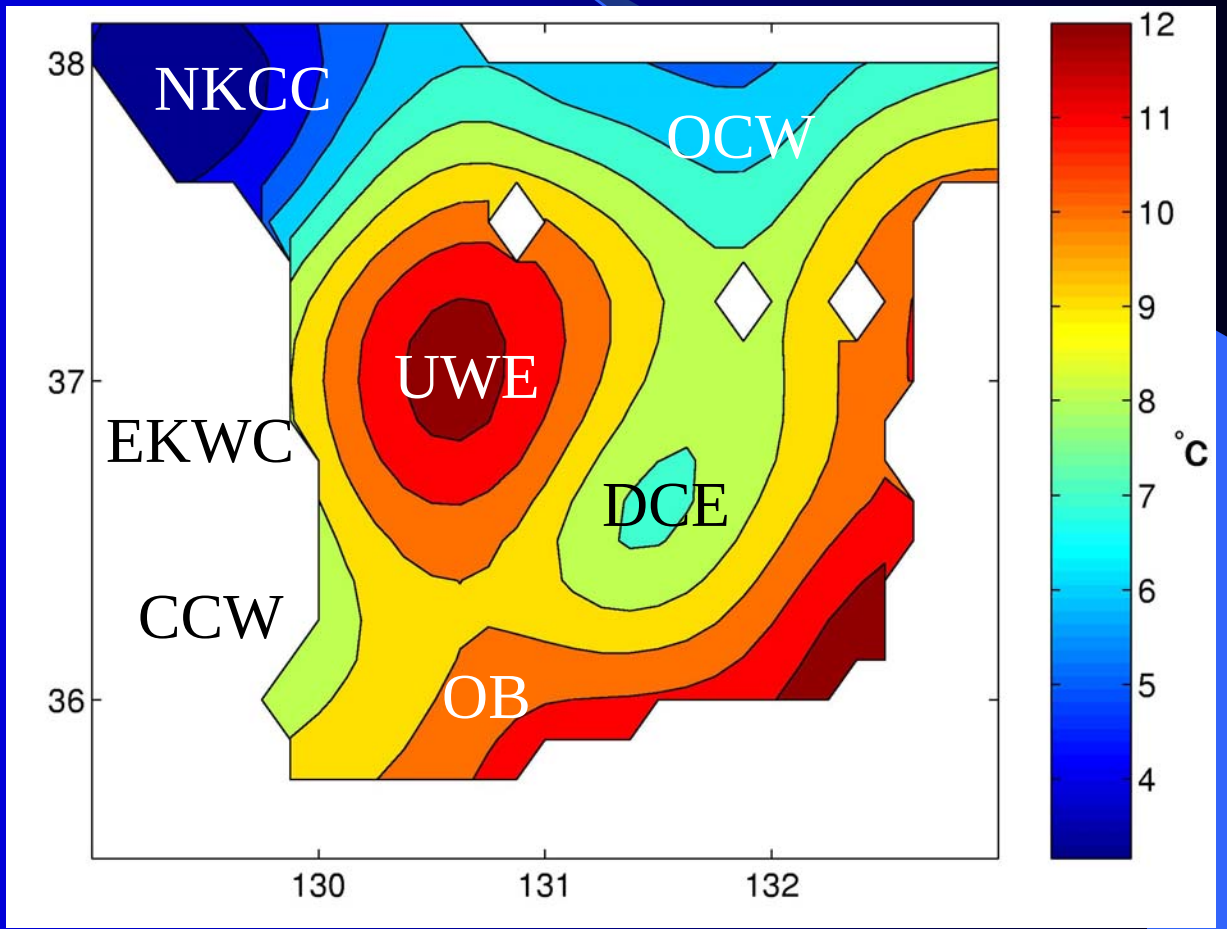

(a) Feb.
(b) Apr.
(c) June
(d) Aug.
(e) Oct.
(f) Dec.
38N
37N
36N
35N
129E
130E
131E
132E


96 02
96 04
96 06
96 08
96 10
96 12
38N
37N
36N
35N
129E
130E
131E
132E
Temperature at 100m

Mean temperature at 100 m between June 1999 and June 2001

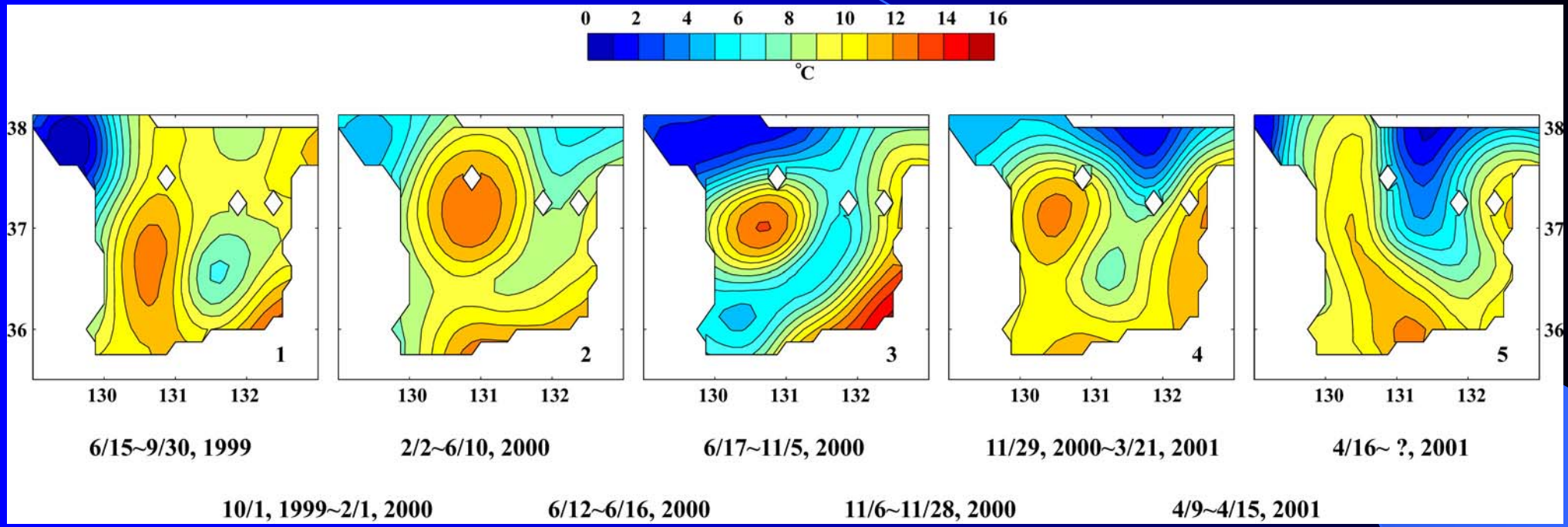
from D. Mitchell

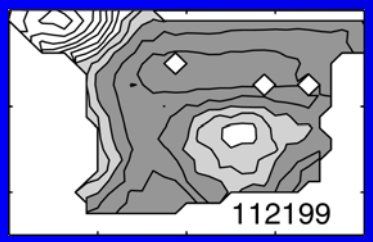




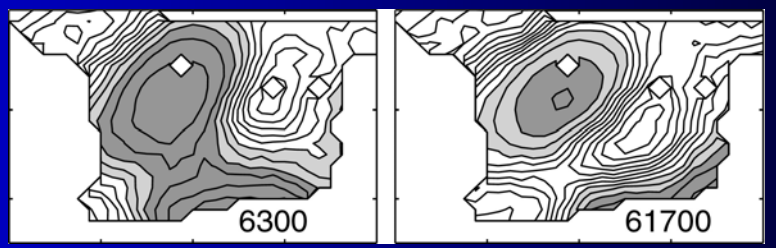
Five flow patterns observed between June 1999 and June 2001

Mitchell et al. (2003)

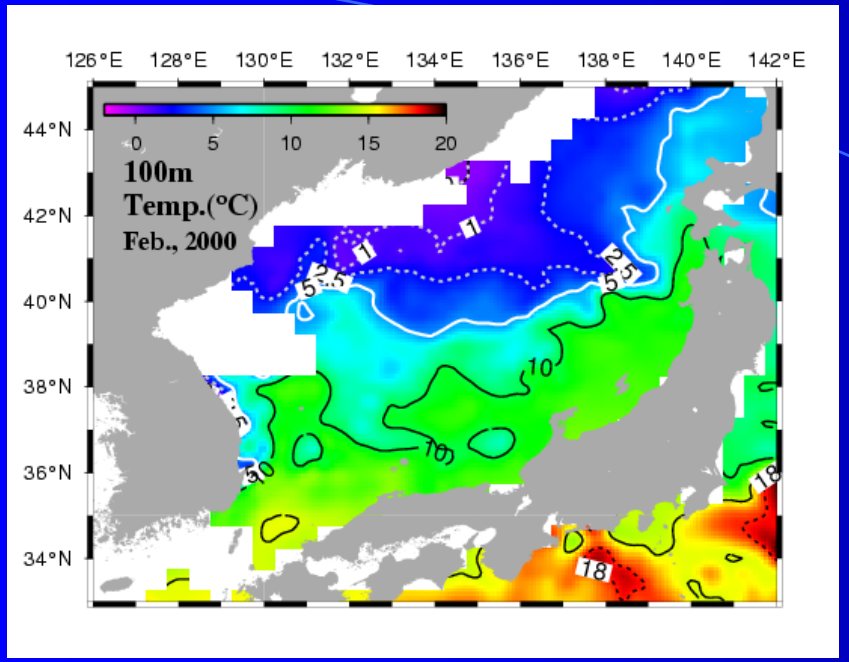


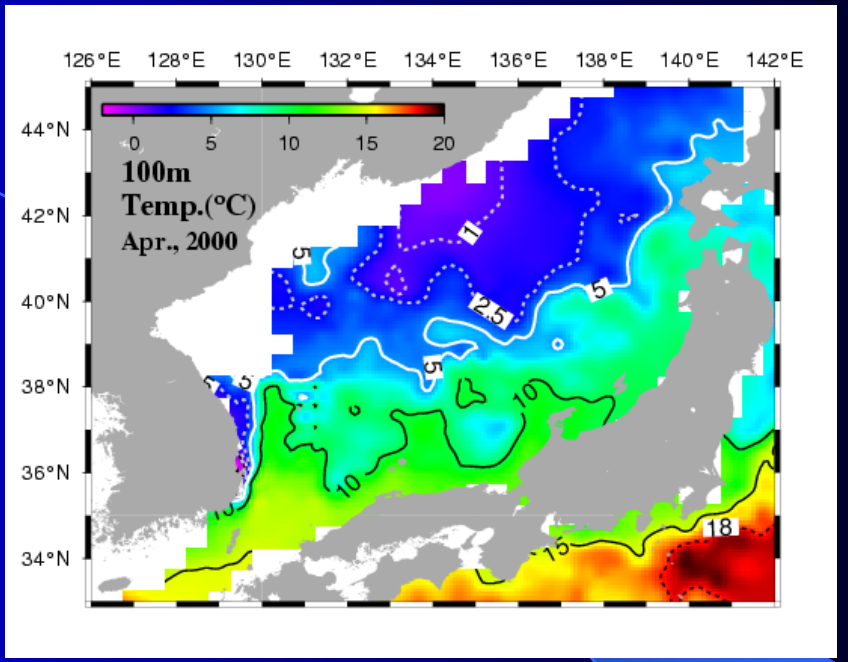


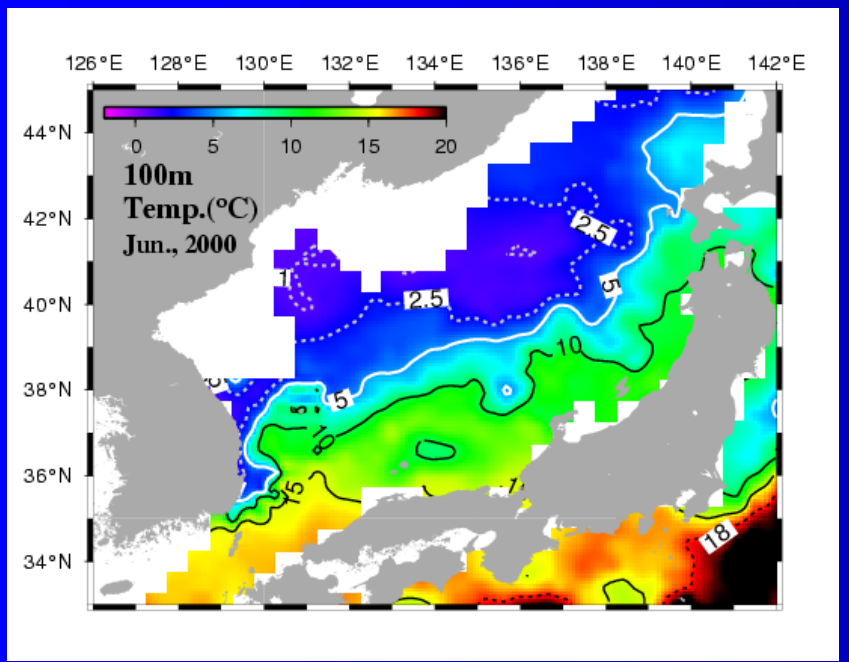
Zonal amplification of the UWE between P1 & P2

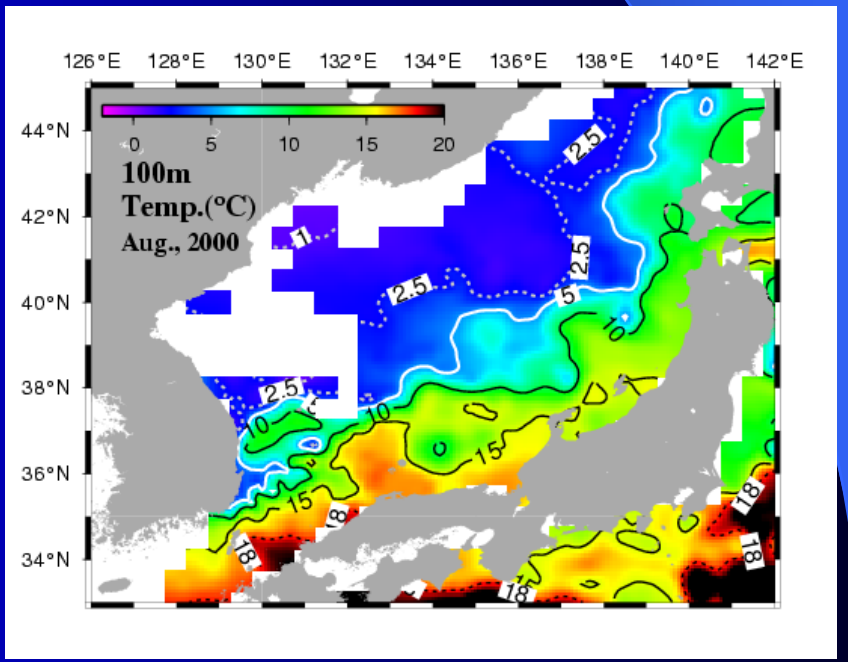


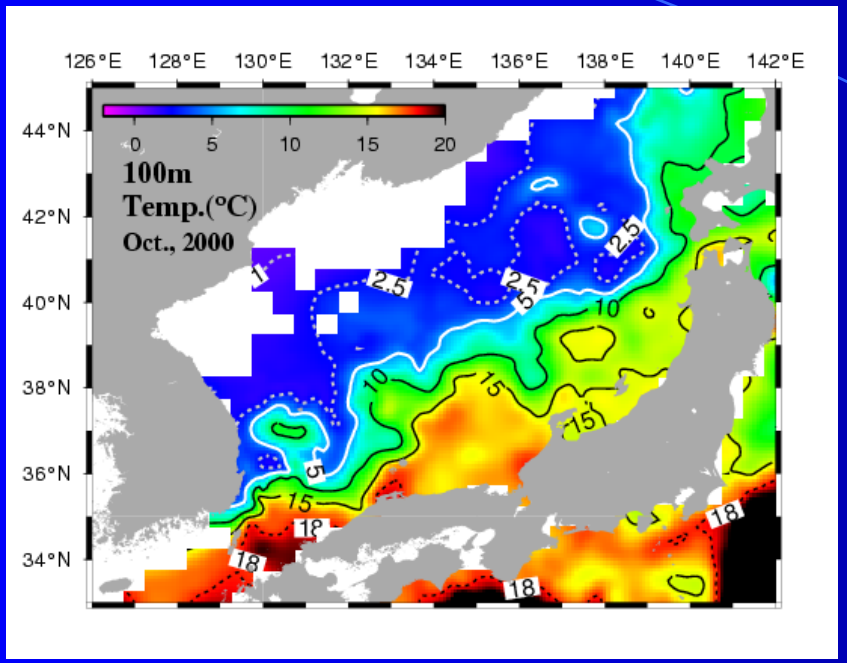
Transition from P2 to P3

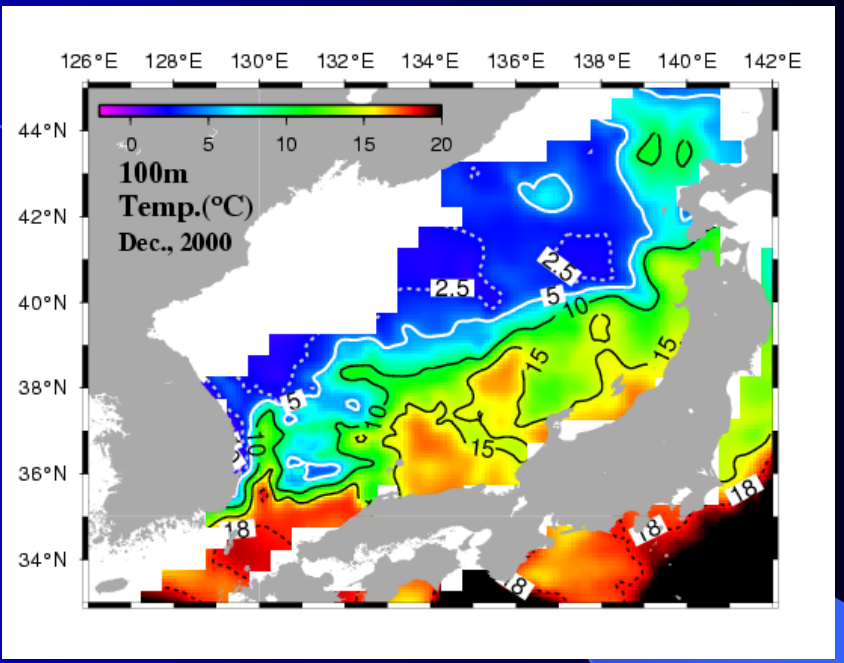

126°E 128°E 130°E 132°E 134°E 136°E 138°E 140°E 142°E
44°N 42°N 40°N 38°N 36°N 34°N
0 5 10 15 20
100m
Temp.(°C)
Feb., 2000

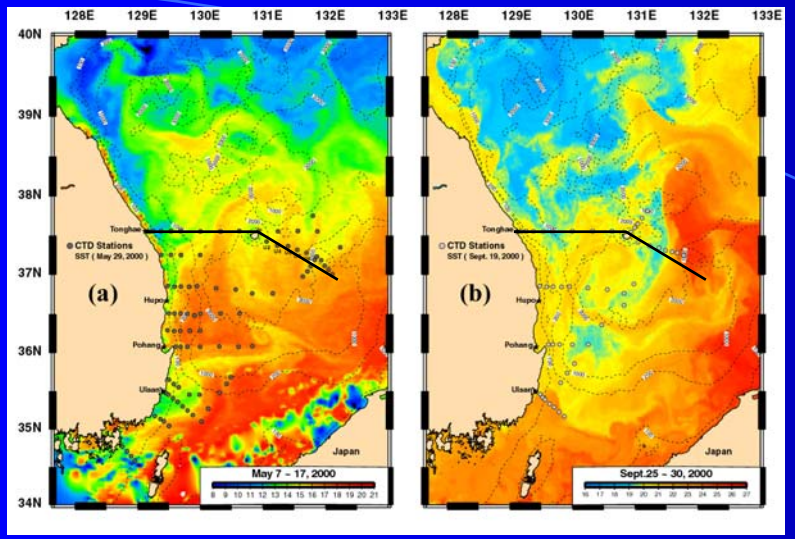

126°E 128°E 130°E 132°E 134°E 136°E 138°E 140°E 142°E
44°N 42°N 40°N 38°N 36°N 34°N
0 5 10 15 20
100m
Temp.(°C)
Apr., 2000


126°E 128°E 130°E 132°E 134°E 136°E 138°E 140°E 142°E
44°N 42°N 40°N 38°N 36°N 34°N
0 5 10 15 20
100m
Temp.(°C)
Jun., 2000


126°E 128°E 130°E 132°E 134°E 136°E 138°E 140°E 142°E
44°N 42°N 40°N 38°N 36°N 34°N
0 5 10 15 20
100m
Temp.(°C)
Aug., 2000

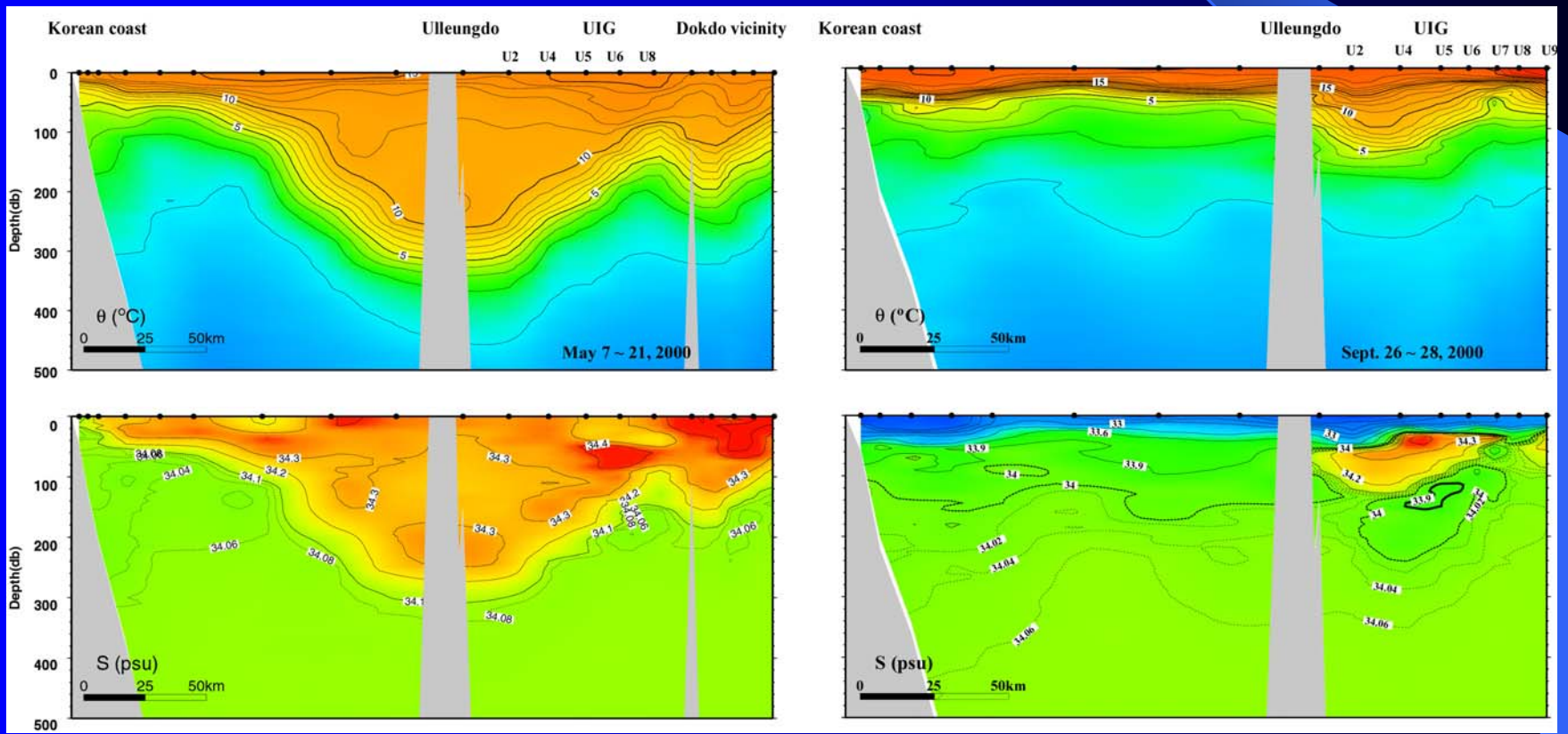

126°E 128°E 130°E 132°E 134°E 136°E 138°E 140°E 142°E
44°N
42°N
40°N
38°N
36°N
34°N
0 5 10 15 20
100m
Temp.(°C)
Oct., 2000


126°E 128°E 130°E 132°E 134°E 136°E 138°E 140°E 142°E
44°N
42°N
40°N
38°N
36°N
34°N
0 5 10 15 20
100m
Temp.(°C)
Dec., 2000

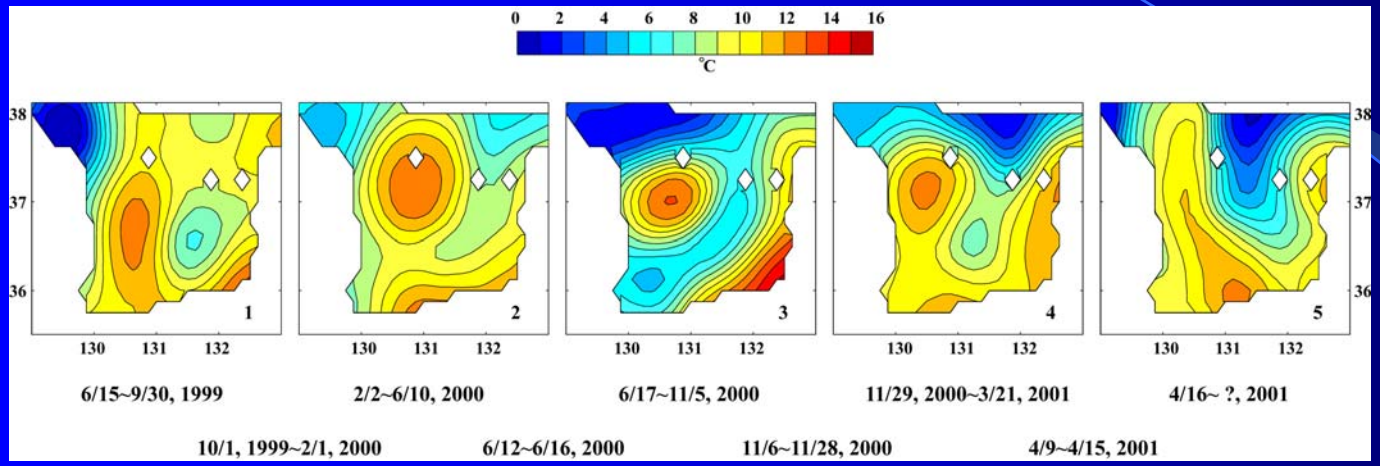


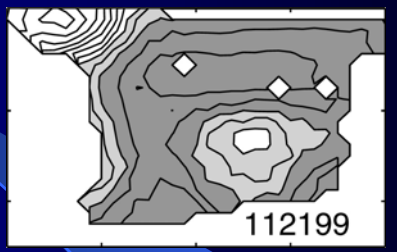
EKWC and UWE

No EKWC

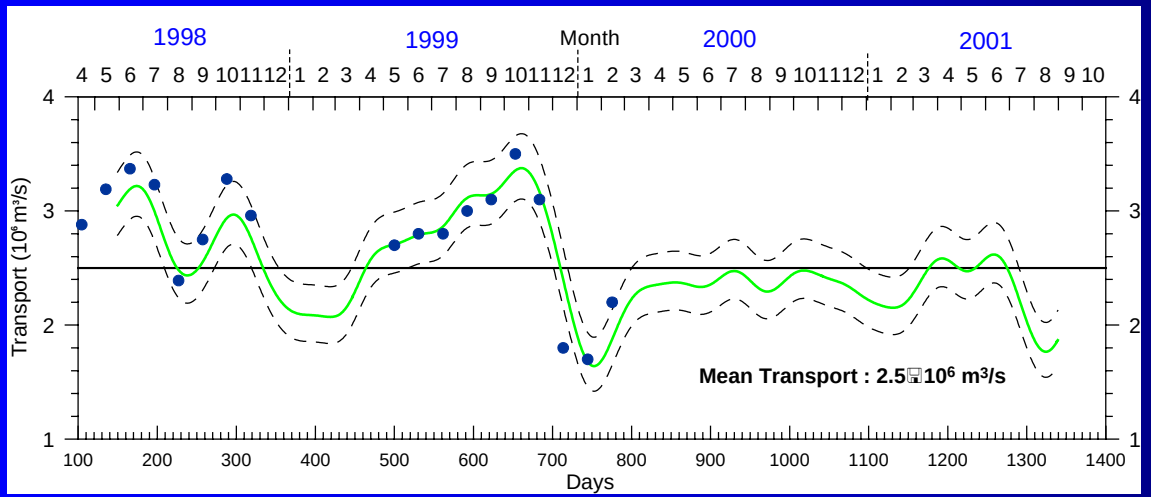


Flow patterns and transport variation





Zonal amplification of the UWE between P1 & P2



Lyu et al. (2003)

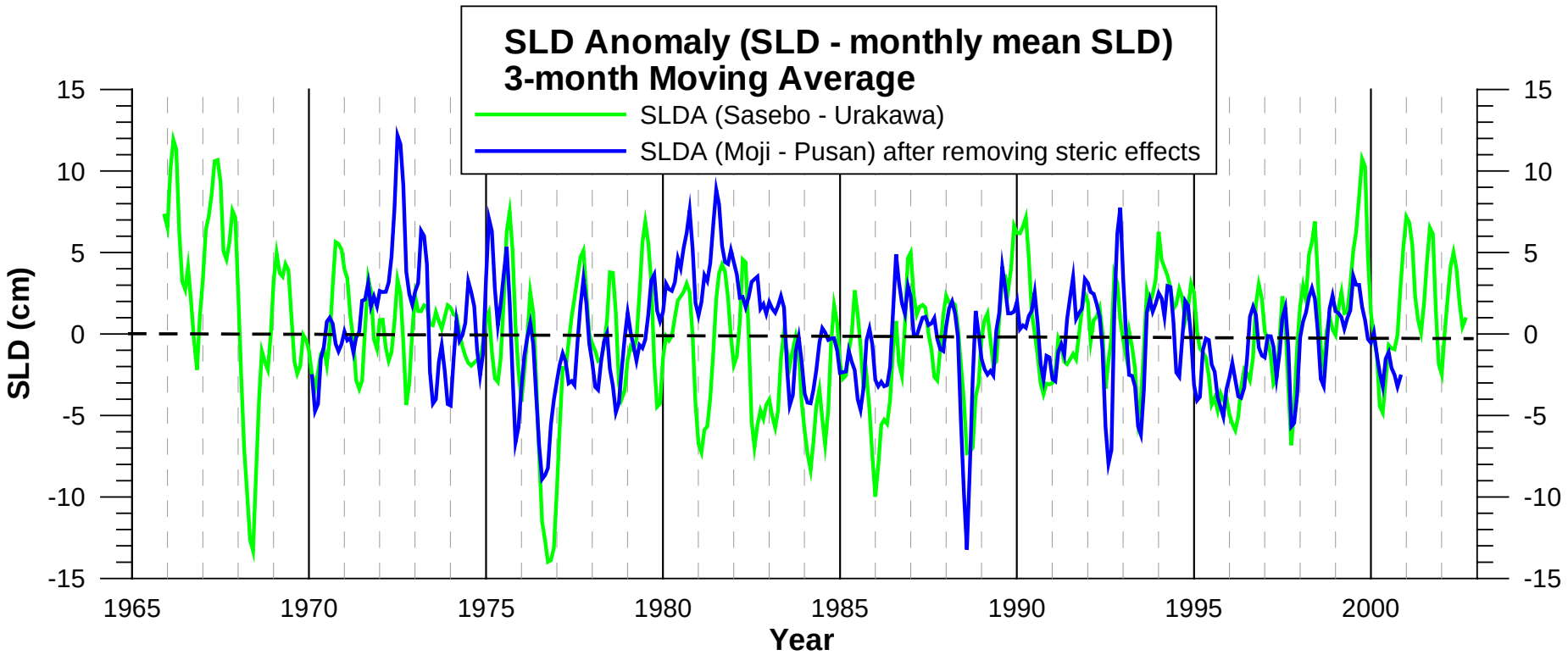
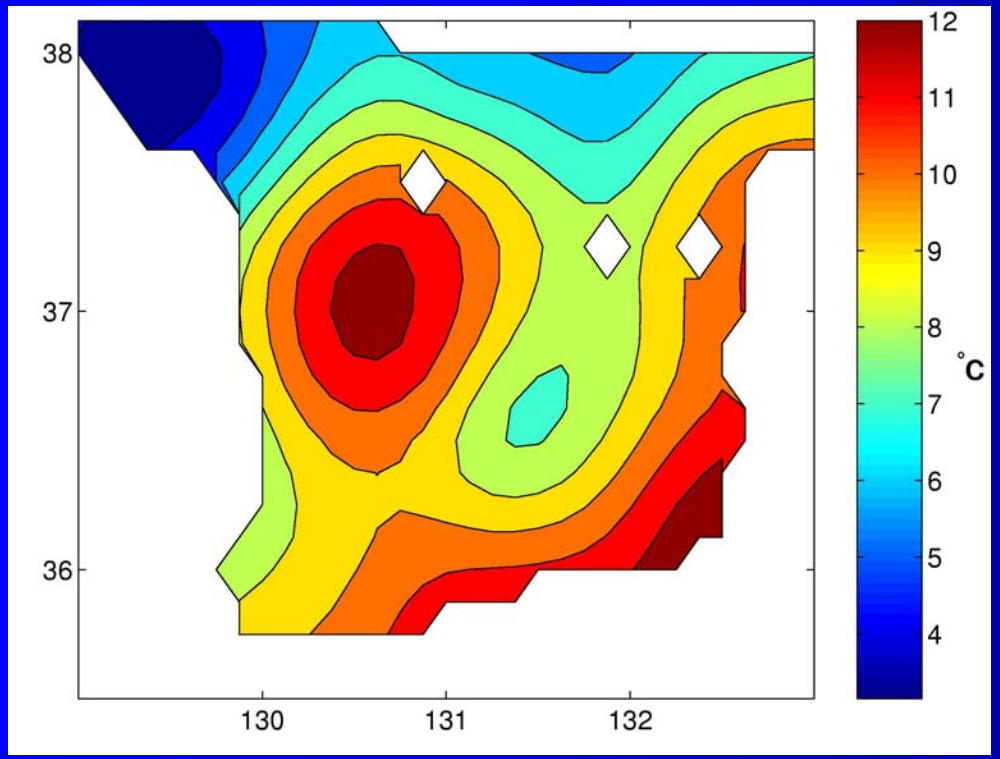
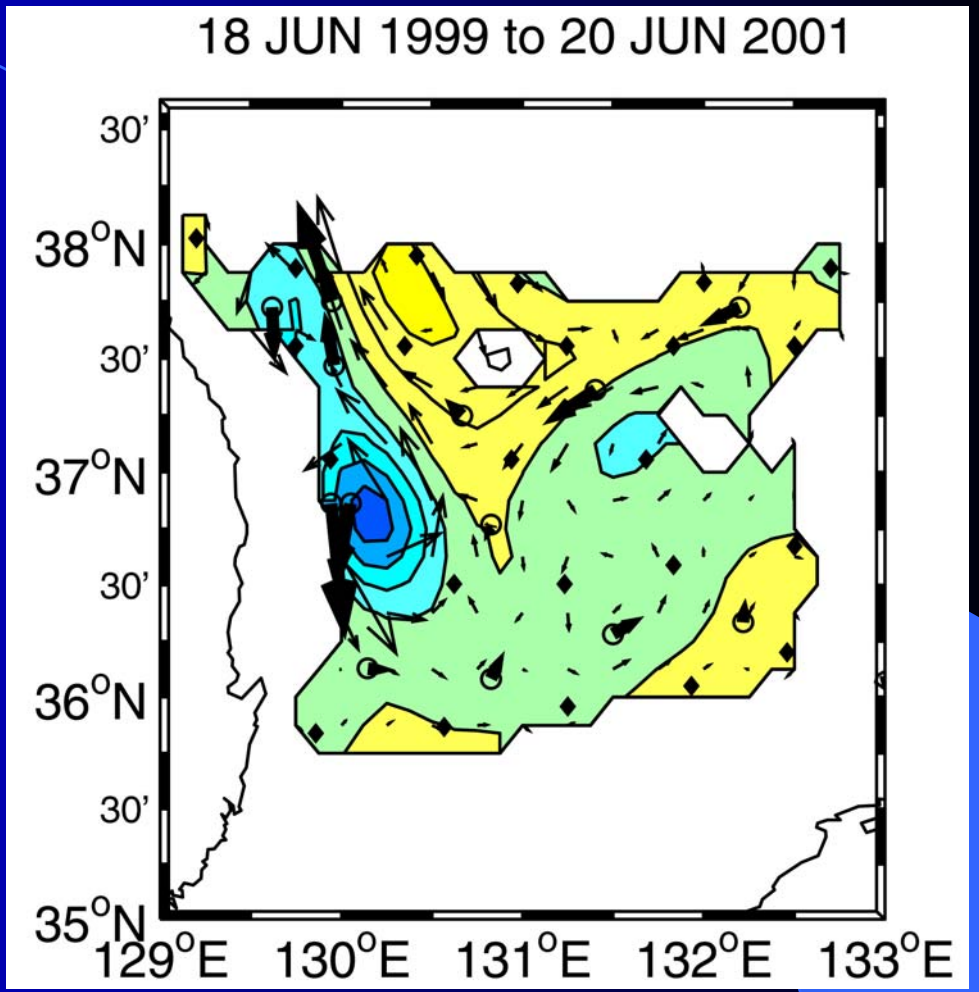


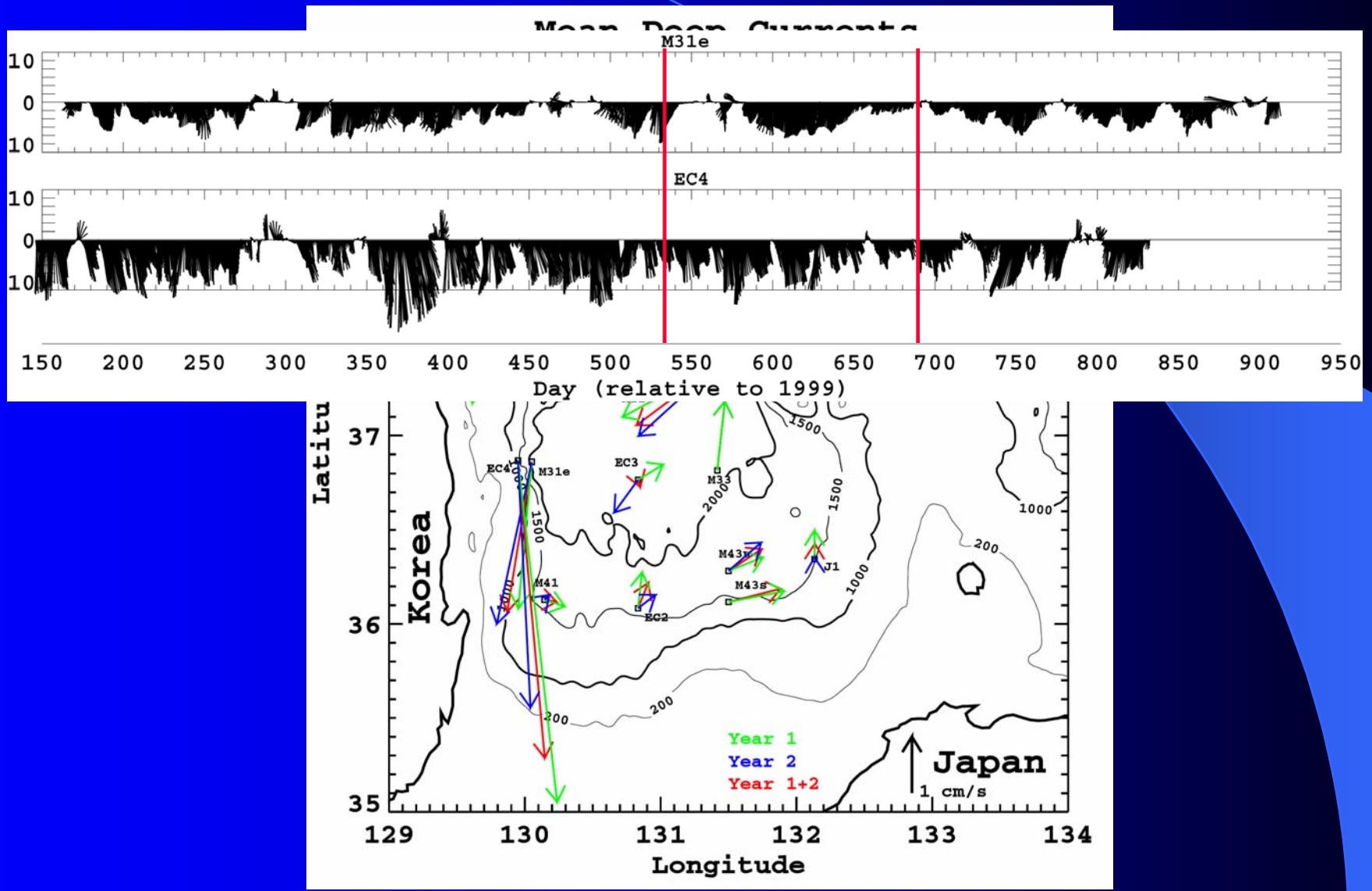
Figure 6.3. Long-term time series of 3-month moving averaged sea level difference anomalies (SLDA) between Sasebo and Urakawa (green line) and Moji and Pusan (blue line). SLDA is given by subtracting monthly mean SLD from monthly SLD after low-pass filtering with a half-power period of 90 days to remove seasonal variations. Baroclinic parts, which are calculated from hydrographic data across the Korea Strait (Lyu and Kim, 2003), are removed from SLD between Moji and Pusan before calculating SLDA.

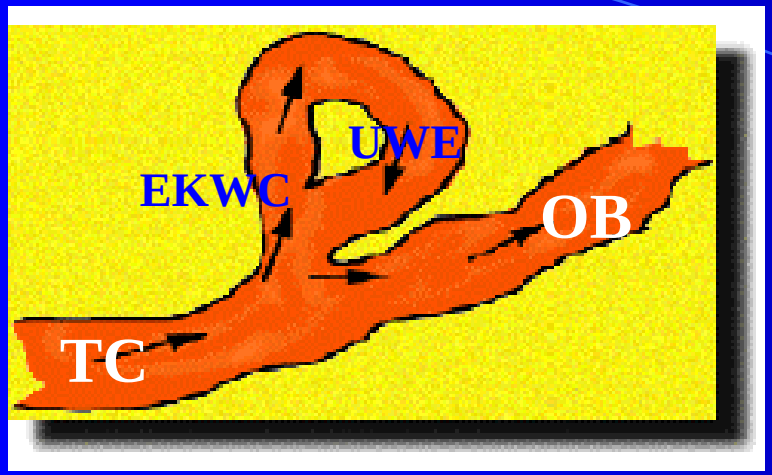
From Lyu (2003)


38
37
36
130
131
132
12
11
10
9
8
7
6
5
4
°C

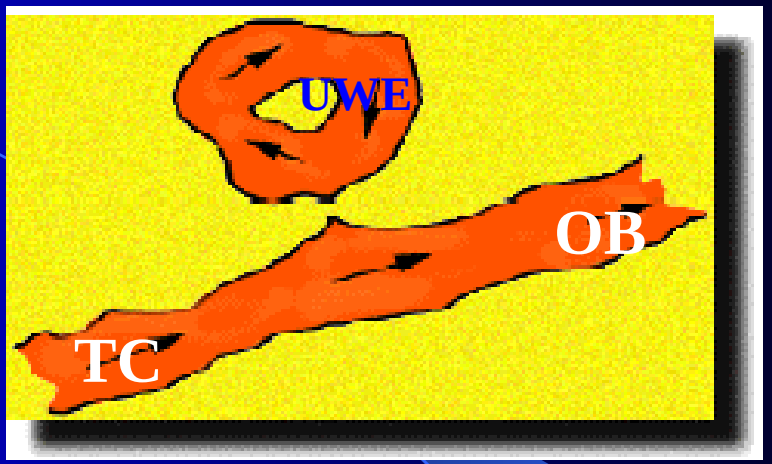

18 JUN 1999 to 20 JUN 2001
30'
38°N
30'
37°N
30'
36°N
30'
35°N
129°E
130°E
131°E
132°E
133°E

Variability of Undercurrent

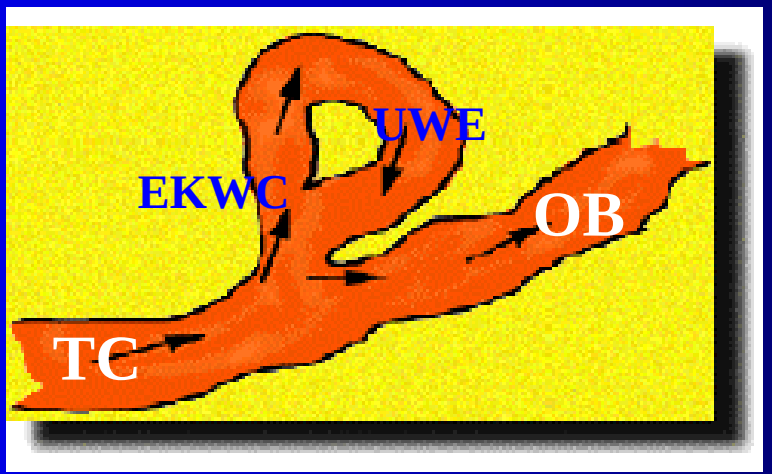




EKWC meander develops and begins to pinch off.



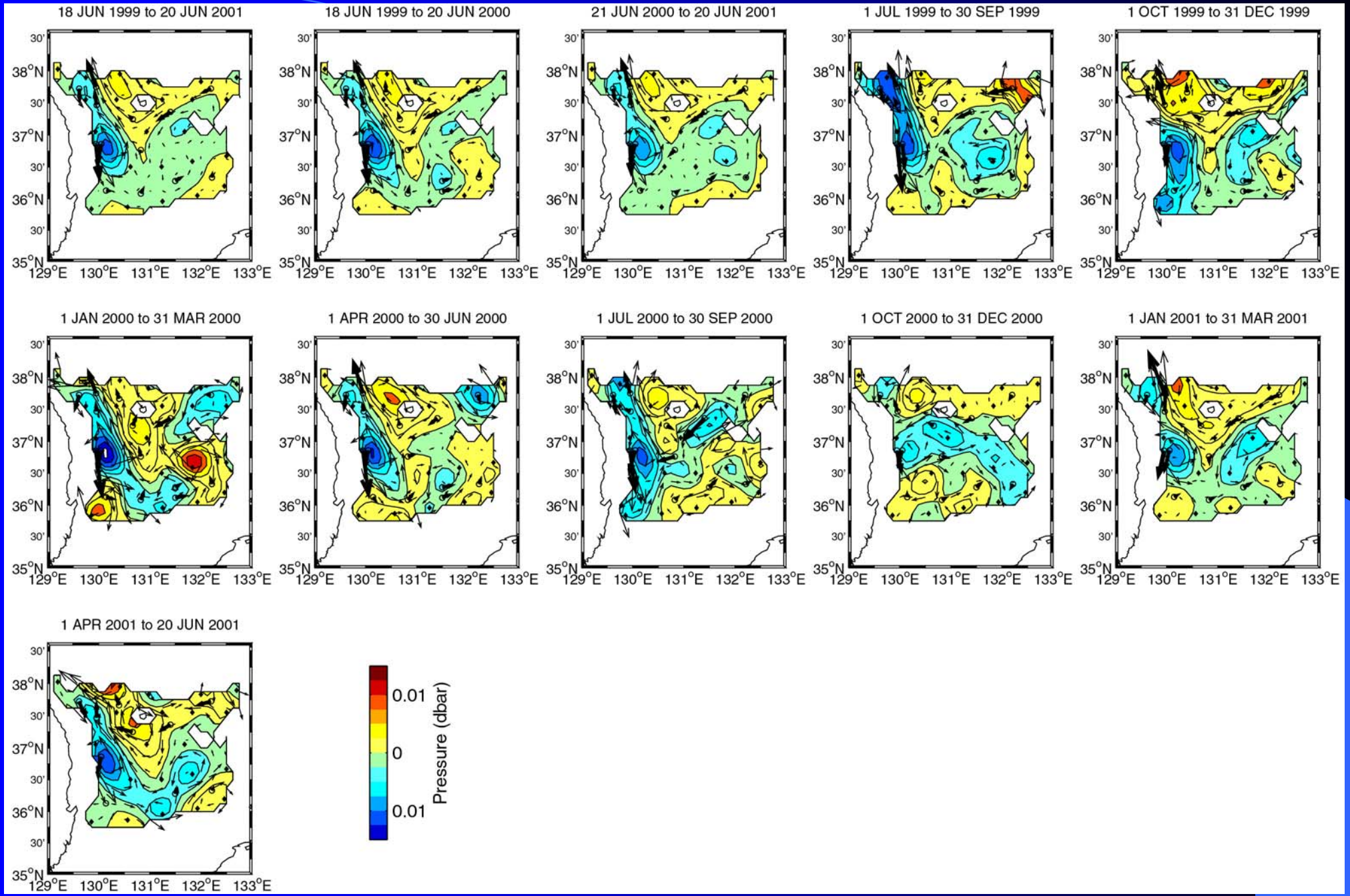
UWE separates from the TC and EKWC disappears.



EKWC is re-established and wraps the UWE.

Summary & Discussions

- Disappearance of the EKWC: The Tsushima Current through the Korea Strait turns to the east downstream of the strait and flows northeastward along the west coast of Japan. Isolated UWE remains in the Ulleung Basin.
- Continuous IES observation for two years: the disappearance occurred during June ~ November, 2000 after merging of cold eddy with coastal cold water.
- Abnormally cold upper layer temperature (T_{100}<5°) in the UB that occurred
that occurred in 1981and 2000 arises from the disappearance of
rises from the disappearance of the EKWC.
obvious, but the basin-averaged T showed its minimum in
or October.
r.
ion of the disappearance: ~5 months, sub-annual scale
onths, sub-annual scale
andering jet


18 JUN 1999 to 20 JUN 2001
18 JUN 1999 to 20 JUN 2000
21 JUN 2000 to 20 JUN 2001
1 JUL 1999 to 30 SEP 1999
1 OCT 1999 to 31 DEC 1999
1 JAN 2000 to 31 MAR 2000
1 APR 2000 to 30 JUN 2000
1 JUL 2000 to 30 SEP 2000
1 OCT 2000 to 31 DEC 2000
1 JAN 2001 to 31 MAR 2001
1 APR 2001 to 20 JUN 2001
35°N
36°N
37°N
38°N
30'
129°E
130°E
131°E
132°E
133°E
0.01
0
0.01
Pressure (dbar)